Forest Health Protection

Pacific Southwest Region
Northeastern California Shared Service Area

Date: June 3, 2022
File Code: 3420

To: District Ranger, Hat Creek Ranger District, Lassen National Forest

Subject: Stand conditions with respect to forest insects and diseases within the Soldier Mountain Project (FHP Report NE22-04)

Report Summary

- All tree species are experiencing extreme moisture stress, especially ponderosa pine, sugar pine and incense cedar, as evidenced by reduced growth, dieback, and death of individual trees (Figure 1).
- Ponderosa pine mortality is widespread due to drought, foliar feeding insects and western pine beetle attacks.
- Overstocked stands, abundant dead and down material and dense brush has put the entire project area at risk to stand replacing wildfire.
- Thinning, mastication and prescribed fire are all recommended to improve tree health and vigor and reduce surface and ladder fuels.

Figure 1. Dead and dying ponderosa pine in Soldier Mountain project area, 2022.

Background

At the request of Tami Taylor, NEPA Planner, Hat Creek Ranger District, Lassen National Forest, Danny Cluck, Forest Health Protection Entomologist, conducted a field evaluation of the Soldier Mountain project on February 24 and May 26, 2022. The objective of these visits was to evaluate existing stand conditions, document current insect and disease activity and consider treatment alternatives. Recommendations provided in this report will assist in the formulation of silvicultural prescriptions that reduce stand density, reduce ladder fuel, and provide for a more drought tolerant and fire resilient species composition.

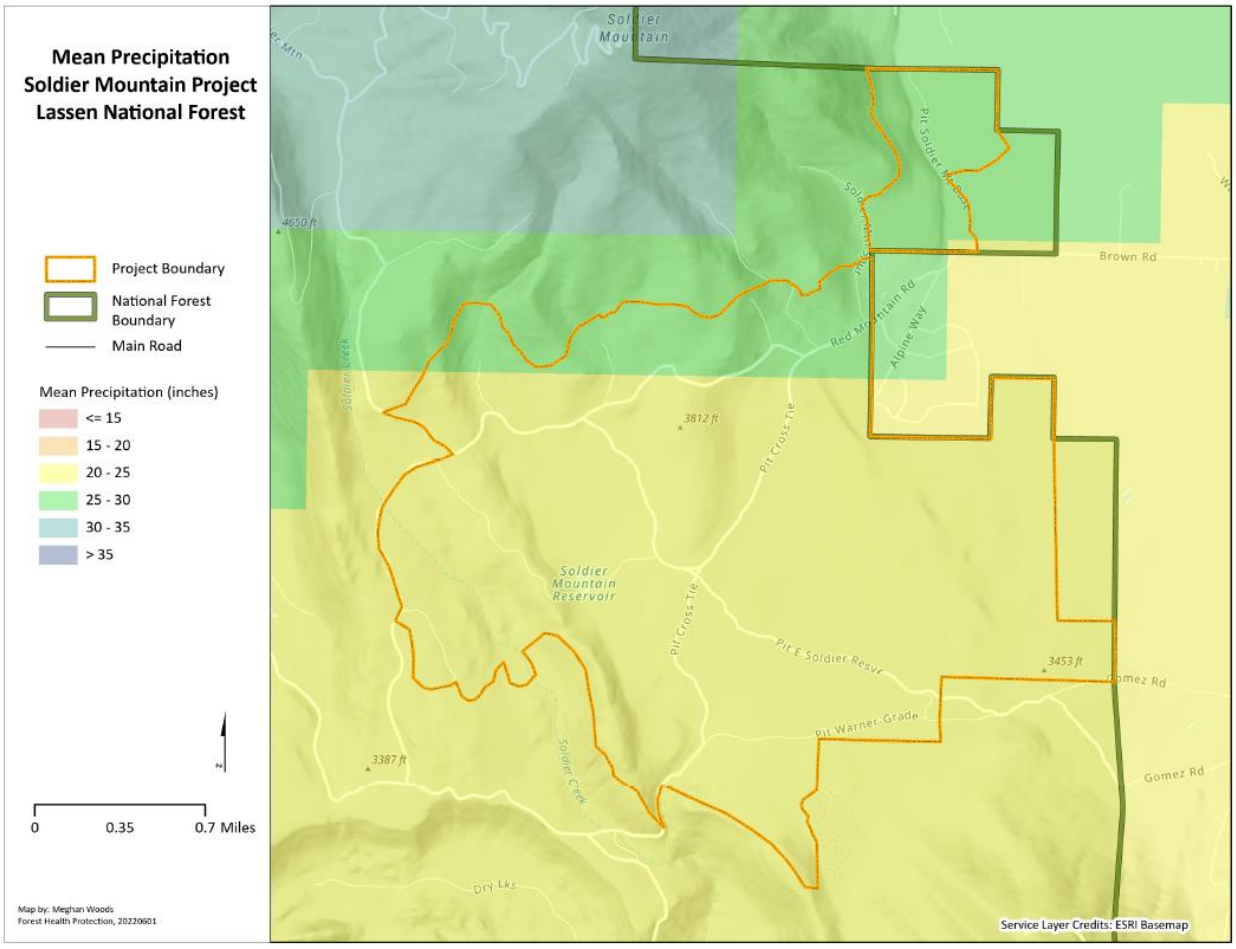
Danny Cluck
Forest Entomologist
530-708-2770
Daniel.Cluck@usda.gov

Bill Woodruff
Plant Pathologist
530-252-6880
william.woodruff@usda.gov

Description of the project area

The Soldier Mountain project is about 6 miles northwest of Fall River Mills, CA at elevations ranging between 3,300 and 4,500 feet (41.0496° N and 121.5507° W). Annual precipitation ranges between 20 and 30 inches (Figure 2). Most of the lower elevation area is mixed hardwood and conifer with scattered individuals and groups of ponderosa pine (*Pinus ponderosa*) growing on presumably deeper soil pockets. These areas as mostly dominated by Oregon white oak (*Quercus garryana*) and gray pine (*Pinus sabiniana*) with abundant brush species and scattered western juniper (*Juniperus occidentalis*). Upper elevation sites mostly consist of ponderosa pine stands with scattered hardwoods including California black oak (*Quercus kelloggii*). There is also one small area of mixed conifer consisting of ponderosa pine, incense cedar (*Calocedrus decurrens*), Douglas-fir (*Psuedotsuga menziesii*), and sugar pine (*Pinus lambertiana*). Most of the forested areas are densely stocked, have experienced elevated levels of tree mortality associated with insects, pathogens and drought and contain high numbers of standing and down dead trees.

Figure 2. Mean annual precipitation for the Soldier Mountain project and surrounding area.



Forest insect and disease conditions

Bark beetle activity observed was primarily on ponderosa pine where western pine beetle (*Dendroctonus brevicomis*) is causing high and increasing levels of tree mortality throughout the project area (Figure 3). Older pockets of mortality from drought in 2015-2017 were observed in a couple of locations (Figure 4).

Figure 3. Ponderosa pine killed by western pine beetle in Soldier Mountain project area, 2022.

Pine engraver beetle (*Ips pini*) and/or California fivespined ips (*Ips paraconfusus*) are causing top kill in many ponderosa pines.

Sugar pines were observed dying throughout the mixed conifer area due to attacks by California flatheaded borer (CFB)(*Phaenops californica*). This level of CFB activity in sugar pine has not been observed in northeastern CA and is an example of the extreme drought impacting this drier growing site.

Figure 4. Old pocket of ponderosa pine mortality caused by western pine beetle, Soldier Mountain project area, 2022.

Dwarf mistletoes, western dwarf mistletoe (*Arcuethobium campylopodum*) on ponderosa pine (Figure 5) and gray pine dwarf mistletoe (*Arcuethobium occidentale*) on gray pine were observed within the project area. Neither appeared to be abundant and playing a significant role in tree mortality. However, a few heavily infested gray pine have died over the past several years in combination with woodboring beetles.

Figure 5. Western dwarf mistletoe infection on ponderosa pine, Soldier Mountain project area, 2022.

Black pineleaf scales (*Nuculaspis californica*) (Figure 6) and needle feeding by Scythropus weevils (*Scythropus californicus*) were found in ponderosa pine reducing live needle complement in affected trees and increasing susceptibility of trees to western pine beetle attacks.

Other insects and diseases observed causing branch dieback, top-kill and whole tree mortality included Douglas-fir engraver beetle (*Scolytus unispinosus*) and flathead fir borer (*Phaenops drummondi*) in Douglas fir and suspected white pine blister rust (*Cronartium ribicola*) in sugar pine.

Incense cedar mortality was observed that appeared to be caused by drought and frost killing of foliage (Figure 7).

Figure 6. Ponderosa pine foliage with black pineleaf scale infestation, Soldier Mountain project area, 2022.

Figure 7. Incense cedar killed by drought and frost injury, Soldier Mountain project area, 2022.

Stand conditions and mortality related to recent and future climate trends

Most stands in the Soldier Mountain project area are above "normal" stocking levels and have exhibited elevated levels of tree mortality caused by bark beetles, especially during periods of drought (Table 1, Figures 8 and 9). The thick undergrowth of brush species is also adding to competition for soil moisture and increasing tree stress. The recent tree mortality combined with high stand density and thick brush has resulted in heavy fuel loading in many areas and a corresponding increase in potential fire behavior. For Table 1, mortality mapped in 2017 was

Table 1. Acres with mortality, estimated dead trees per acre and estimated total # of dead trees from R5 Aerial Detection Surveys and Palmer Hydrologic Drought Index (PHDI) (average of CA Divisions 2 and 3[1]) by water year (Oct-Sept) within the Soldier Mountain project area. No mortality flights in 2020.

Year	Acres	Dead Trees/Acre	Total # of Dead Trees	PHDI[2]
2021	766		**7,938**	**-4.23**
2020	NA	NA	NA	-1.45
2019	0		0	0.99
2018	0		3	-0.83
2017	610		3,624	3.03
2016	598		5,747	-1.32
2015	324		349	-3.34
2014	4		13	-3.56
2013	113		309	-2.16
2012	0		0	-0.59

[1] California Divisions 2 and 3 encompass most of northeastern California. The Soldier Mountain project area is close to the border between these two zones.

[2] PHDI values ranging from -2.00 to -2.99 are considered moderate drought conditions. Severe drought conditions range from -3.00 to -3.99 and extreme drought conditions are below -4.00.

Figure 8. Number of dead trees per acre from 2012 to 2021 in Soldier Mountain project area. Data from 2020 not available for this analysis but would likely increase mortality in all previously mapped areas.

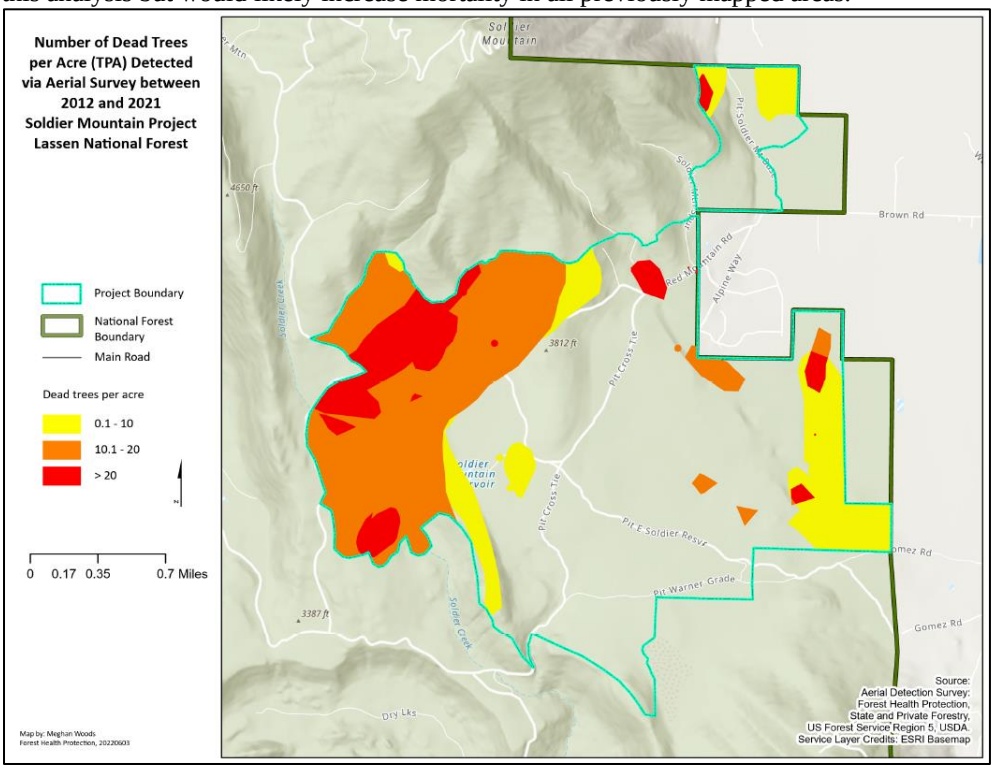
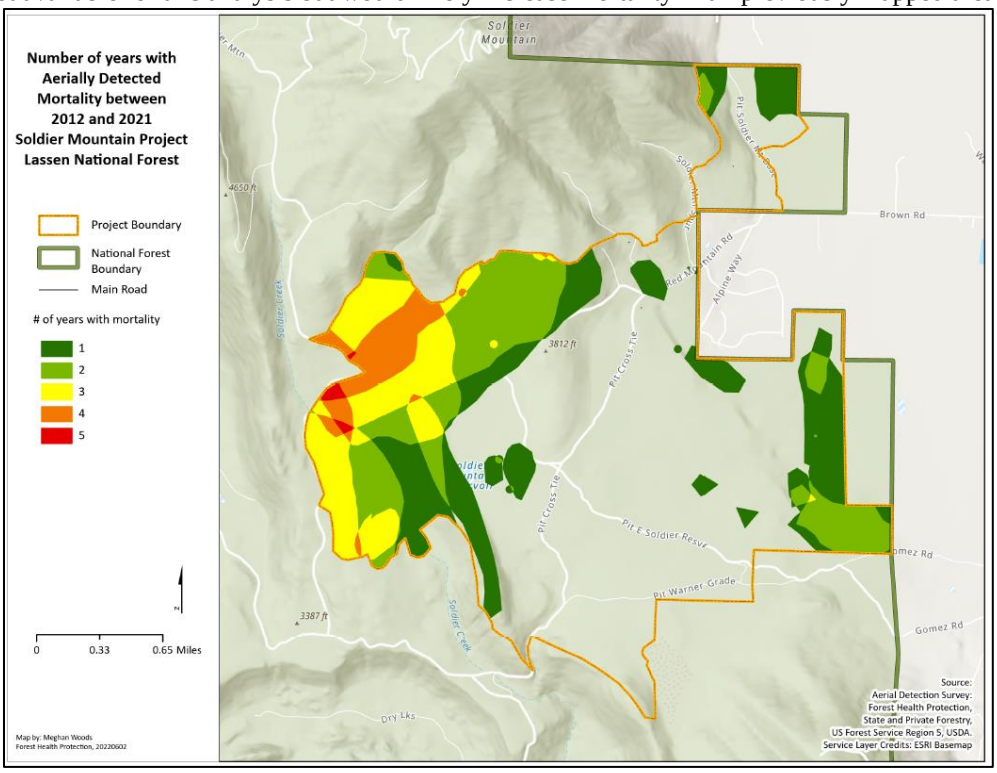


Figure 9. Number of years with mapped tree mortality from 2012 to 2021 in the Soldier Mountain project area. Data from 2020 not available for this analysis but would likely increase mortality in all previously mapped areas.



the result of trees attacked in 2016 (before a return to above average precipitation in 2017). The water year of 2020-2021 was the driest on record (lowest Palmer Hydrologic Drought Index Value) for CA Divisions 2 and 3.

Predicted climate change is likely to impact trees growing in the Soldier Mountain project area by the end of the century. Although no Lassen National Forest specific climate change models are available at this time, there is a consensus among California models that summers will be hotter and drier than they are currently. This prediction is based on the forecasted rise in mean minimum and maximum temperatures and remains consistent regardless of future levels of annual precipitation (K. Merriam, *Lassen National Forest Climate Change Trend Summary 2022*. The risk of bark beetle caused tree mortality will likely increase for all conifer species under this scenario. Improving the resilience of stands to future disturbance events through density, size class and species composition management will be critical to maintaining a healthy forested landscape. The current drought has provided a telling example of the impacts of warming and drying on tree growth and mortality. The short needle length for 2021 in ponderosa pine, significantly reduced from previous years (Figure 10), and the California flatheaded borer activity in sugar pine both indicate extreme tree stress. There is a chance that some lower elevation areas will not be suitable for ponderosa pine in the future.

Considerations for thinning treatments

The best strategy to decrease the amount of additional mortality is to reduce stand density through thinning. Thinning will increase the health and vigor of residual trees by reducing competition for limited soil moisture (Fettig et al. 2007). Mechanical thinning is recommended for the initial treatment to reduce stand density and ladder fuels that will allow long-term maintenance with prescribed fire without causing excessive mortality of residual trees. This includes patches of ponderosa pines within hardwood dominated forests.

Figure 10. Extreme needle growth reduction in 2021 due to drought, Soldier Mountain project area, 2022.

When planning thinning treatments, it should be recognized that the target stand density and species composition is an average to be applied across the landscape and some variability may be desired. Individual high-value trees, such as mature pines, and drier areas dominated by ponderosa pine should benefit by having the stocking reduced to lower levels. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as forked and/or broken-topped trees. Tree removal should include trees heavily infected with dwarf mistletoe, root disease and trees infested with bark beetles. At lower elevation sites where ponderosa pine is showing signs of extreme stress and mortality, oak species should be favored for retention.

Keeping ponderosa stands below SDI 230, the defined threshold for the zone of imminent bark beetle-caused mortality (Oliver 1995), has historically proven effective. However, drier conditions over the past 20 years have challenged existing thresholds and recent observations of tree mortality

during outbreaks have suggested that these prior recommendations may no longer be sufficient in providing protection against bark beetle-caused mortality. Recent analysis of several bark beetle outbreaks in ponderosa pine dominated forests suggest much lower stocking levels are needed to minimize bark beetle activity. Specifically, their analysis indicated that the resistance levels suggested in earlier studies at 200 SDI were insufficient to provide for either a high-level, or moderate level, of resistance when challenged by severe beetle pressure levels. Overall, results indicated substantially lower stand density levels <100 SDI are needed to promote high-level resistance, and <150 SDI to promote moderate-level resistance, to severe *Dendroctonus* spp. population pressure that has been documented during primarily dry time segments from 2000-2018. These resistance thresholds for low, moderate, and high protection against mortality during outbreaks, in terms of tree diameter and spacing, are listed in Appendix A. Incorporating these different stocking levels into a heterogeneous treatment of existing pine stands should provide a higher level of protection from drought and bark beetles while allowing for successful reintroduction of low intensity prescribed fire.

Recent research by Hood et al 2016 suggest the combination of thinning and prescribed burning provided both short and long-term benefits to ponderosa pine stands by increasing and maintaining their resistance to bark beetle-caused mortality. Thinned and burned treatments experienced lower ponderosa pine mortality than burn-only and untreated control plots during a subsequent mountain pine beetle outbreak. Treatments that lead to more open forests tend to have fewer bark beetle susceptible trees and stand structure that allows for faster diffusion and subsequent loss of beetle-produced aggregation pheromones that inhibit attacks. The thin-only treatment also experienced lower ponderosa pine mortality but lacked the beneficial longer-term effects of prescribed fire in reducing tree recruitment and introducing spatial heterogeneity that mechanical treatment alone could not accomplish. Other studies have also shown that prescribed fire effects on tree physiology can included increases in resin flow that increase resistance to bark beetle attacks and these effects can last for up to 10 years (Hood and Sala 2015 *cited in Hood et al 2016*). In addition, burning also affects nutrient cycling, spatial heterogeneity for wildlife habitat, and resilience from other disturbances that may also be important for perpetuating the ecosystem in the long-term (Bond and Keeley 2005, Gundale et al. 2005, Fiedler et al. 2010, Ryan et al. 2013 *cited in Hood et al 2016*) and which cannot be replicated by mechanical treatments alone (McIver et al. 2013, Stevens et al. 2014 *cited in Hood et al 2016*).

No evidence of Heterobasidion root disease was found within the Soldier Mountain project area but a systematic survey was not conducted. Applications of a registered borate compound to all freshly cut pine stumps >14” in diameter may not be necessary to reduce the chance of creating new infection centers of *Heterobasidion irregulare* in pine stands since it appears there are no known or suspected root disease pockets with 1/3 mile of treatment units. Stumps created along roadways and infrastructure are a higher priority for treatment regardless of species and may warrant applications depending on level of concern for the potential of creating new root disease pockets that may lead to future hazard trees. Please refer to the new borate treatment recommendation table (Appendix A) for additional guidance.

Additional considerations for Rx fire

If prescribed fire is used as a follow-up treatment to stand thinning or as a standalone treatment, unacceptable levels of large diameter pine mortality may occur depending on management objectives. This mortality most often occurs as a direct result of cambium or crown injury to individual trees during the fire. Mature ponderosa pine, and especially sugar pine, are susceptible to mortality during prescribed burns because of the deep duff and litter that has accumulated at their base in the absence of fire. These duff mounds typically burn at a slow rate, while maintaining lethal temperatures, causing severe cambium injury. To protect individual large diameter pine from lethal cambium injury, raking the duff away from the bases of these trees before burning (within 24" of the bole and down to mineral soil) is recommended. Raking is also recommended for large diameter, high-value oak species (or those that have unique wildlife value) that have heavy accumulations of fuel around their base as observations of oaks in several post-fire areas have shown a high degree of cambium injury, without severe crown injury, resulting in extensive tree mortality (Sheep Fire and Dixie Fire, LNF are recent examples).

Potential for funding through the Western Bark Beetle Program

Forest Health Protection may be able to assist with funding, including NEPA activities, for thinning within the Soldier Mountain project areas. Thinning treatments that reduce stand density and change species compositions sufficient to lower the risk to bark beetle-caused mortality would meet the minimum requirements for Western Bark Beetle Program funding and would be supported by this evaluation. If you are interested in this competitive funding please contact me for assistance in developing and submitting a proposal.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-708-2770.

/s/ Danny Cluck

Daniel R. Cluck
Forest Entomologist
NE CA Shared Services Area

cc: Tami Taylor, NEPA Planner, Hat Creek RD
Sarah Oldson, Silviculturist, Cascade Resource Consultants
Forest Health Protection, Regional Office

References

Egan, J.M., 2021. Stand density associated with resistance to *Dendroctonus* spp. following exposure to varied beetle pressures and climactic conditions across western U.S. yellow pine forests from 1959-2016. Book chapter *in review*

Fettig, C.J.; Klepzig, K.D.; Billings, R.F.; Munson, A.S.; Nebeker, T.E.; Negrón, J.F.; Nowak, J.T. 2007. The effectiveness of vegetation management practices for prevention and control of bark beetle outbreaks in coniferous forests of the western and southern United States. Forest Ecology and Management. 238: 24–53.

Hood, S.M., Baker, S. and Sala, A. (2016). Fortifying the forest: thinning and burning increase resistance to a bark beetle outbreak and promote forest resilience. *Ecological Applications* 26(7), 1984-2000.

Oliver, W.W., 1995. Is self-thinning in ponderosa pine ruled by Dendroctonus bark beetles? In: Proceedings of the 1995 National Silviculture, Workshop, GTR-RM-267. U.S. Department of Agriculture, Forest Service, Rocky
Mountain Research Station, Fort Collins, C.O., pp., 213–218.

Riegel, G.M.; Miller, R.F.; Skinner, C.N.; Smith, S.E. (2006) Northeastern plateaus bioregion. In: *Fire in California's Ecosystems*. Edited by N.G. Sugihara, J.W. van Wagtendonk, J. Fites-Kaufman, K.E Shaffer, A.E. Thode. University of California Press, Berkeley. pp. 225-263.

Insect and Disease Information

Western Pine Beetle

The western pine beetle, *Dendroctonus brevicomis*, has been intensivly studied and has proven to be an important factor in the ecology and management of ponderosa pine thoughout the range of the host species (Miller and Keen 1960). This insect breeds in the main bole of living ponderosa pine larger than about 8 inches DBH. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire. Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latidude and elevation, there can be from one to four generations per year.

Evidence of Attack

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Pitch tubes are formed on the tree trunk around the entry holes. Successful pitch tubes are red-brown masses of resin and boring dust. Relativly few, widely scattered white pitch tubes usually indicate that the attacks were not successful and that the tree should survive. Pheremones released during a successful attack attract other conspecifics. Attracted beetles may then spill over into nearby apparently healthy trees and overwhelm the tree with sheer numbers.

Life Stages and Development

These beetles pass thorugh the egg, larval, pupal and adult stages during a life cycle that varies in length dependent primarily on temperature. Adults bore a sinuous gallery pattern in the phloem and the female lays eggs in niches along the sides of the gallery. The larvae are small white grubs that first feed in the phloem then mine into the middle bark where they complete most of their development. Bluestain fungi inoculates the tree during successful attacks, blocking trachids and vessicles which contribute to the rapid tree mortality associated with bark beetle attacks.

Conditions affecting Outbreaks

Outbreaks of western pine beetle have been observed, and surveys made, in pine regions of the Westsince 1899 (Hopkins 1899; cited in Miller and Keen 1960). An insect survey completed in 1917 in northern California indicated that over 25 million board feet of pine timber had been killed by bark beetles.Information from surveys conducted in the 1930's indicated enormous losses attributed to the western pine beetle around that time. During the 1930's outbreak, most of the mortality occurred in stands of mature or overmature trees of poor vigor (Miller and Keen 1960). Group kills do not typically continue to increase in size though successive beetle generation as is typical with Mountain Pine Beetle and Jeffreay Pine Beetle. Rather, observations indicate that emerging beetles tend to leave the group kill area to initiate new attacks elsewhere.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In northeastern California, drought stress may be the key condition influencing western pine beetle outbreaks. When healthy trees undergo a sudden and sever moisture stress populations of western pine beetle are likely to increase. Healthy trees ordinarily produce abundant resin, which pitch out attacking beetles, but when deprived of moisture, stressed trees cannot produce sufficient resin to resist the attack. Any condition that results in excessive demand for moisture, such as inter-tree completion, competing vegetation, or protracted drought periods; or any condition that reduces the ability of the roots to supply water to the tree, such as mechanical damage, root disease or soil compaction, can cause moisture stress and increase susceptibility to attack by the western pine beetle. Woodpeckers, predacious beetles, and low temperatures act as natural control agents when beetle populations are low (endemic populations).

Dwarf mistletoe

Dwarf mistletoes (*Arceuthobium* spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.

Appendix A: Stand density table

Tree-Level SDI Thresholds and Spacing Equivalence to Promote Bark Beetle Resistance within Ponderosa Pines

Note: Spacing Targets Should be Adjusted to Account for Post-Treatment Vegetation Growth throughout the Time Horizon that Resistance is Needed

Based on Meta-Analysis of data from 662 plots covering >60,000 trees 'challenged' by Dendroctonus spp. populations

Tree Diameter	**Minimum Protection: 200 SDI** Assuming a Severe *Dendroctonus* spp. Outbreak: *48% probability of High-Degree Resistance (>90% pine survival)* *69% probability of Moderate-Degree Resistance (>70% pine survival)*			**Moderate Protection: 150 SDI** Assuming a Severe *Dendroctonus* spp. Outbreak: *64% probability of High-Degree Resistance (>90% pine survival)* *84% probability of Moderate-Degree Resistance (>70% pine survival)*			**High Protection: 100 SDI** Assuming a Severe *Dendroctonus* spp. Outbreak: *85% probability of High-Degree Resistance (>90% pine survival)* *95% probability of Moderate-Degree Resistance (>70% pine survival)*			Tree Diameter
(inches)	Trees/acre	Spacing	BA/acre	Trees/acre	Spacing	BA/acre	Trees/acre	Spacing	BA/acre	(inches)
4	870	7	76	653	8	57	479	10	42	4
5	608	8	83	456	10	62	335	11	46	5
6	454	10	89	341	11	67	250	13	49	6
7	355	11	95	266	13	71	195	15	52	7
8	286	12	100	215	14	75	157	17	55	8
9	237	14	105	178	16	78	130	18	58	9
10	200	15	109	150	17	82	110	20	60	10
11	172	16	113	129	18	85	94	21	62	11
12	149	17	117	112	20	88	82	23	64	12
13	131	18	121	98	21	91	72	25	67	13
14	117	19	125	87	22	93	64	26	69	14
15	104	20	128	78	24	96	57	28	70	15
16	94	22	131	71	25	98	52	29	72	16
17	85	23	135	64	26	101	47	30	74	17
18	78	24	138	58	27	103	43	32	76	18
19	71	25	141	54	29	105	39	33	77	19
20	66	26	143	49	30	108	36	35	79	20
21	61	27	146	46	31	110	33	36	80	21
22	56	28	149	42	32	112	31	37	82	22
23	53	29	152	39	33	114	29	39	83	23
24	49	30	154	37	34	116	27	40	85	24
25	46	31	157	34	36	117	25	42	86	25
26	43	32	159	32	37	119	24	43	88	26
27	41	33	161	30	38	121	22	44	89	27
28	38	34	164	29	39	123	21	45	90	28
29	36	35	166	27	40	125	20	47	91	29
30	34	36	168	26	41	126	19	48	93	30
31	33	37	171	24	42	128	18	49	94	31
32	31	38	173	23	43	130	17	51	95	32
33	29	38	175	22	44	131	16	52	96	33
34	28	39	177	21	45	133	15	53	97	34
35	27	40	179	20	47	134	15	54	98	35

Contact Joel Egan, FHP Group Leader, joel.egan@usda.gov, 406-329-3278 for details on using this chart

Table provides the trees/acre, spacing, and basal area equivalence across constant 200, 150, or 100 SDI levels, respectively

Priorities for stump borate treatments to prevent Heterobasidion Root Disease (HRD) v.4.5
Contact your Forest Health Protection Entomologist or Plant Pathologist for assistance

USFS Region 5 - BORATE STUMP TREATMENT PRIORITY BY FOREST CONDITION and HARVEST ACTIVITY			
Priority	**HARVEST ACTIVITY in FOREST TYPE and CONDITION**	***TREAT WHICH STUMPS?**	**WHY**
Very Low	Salvage high severity burn (nearly all trees killed); plant	NONE	Little connectivity with seedling roots; Most dead roots get infected with competing organisms before seedling roots contact them
Very Low	Clearcut PP/JP, true fir or mixed conifer; any location including roadsides and powerline corridors	NONE	Very low probability of new establishing new infection centers
Very Low	Thin true fir which has widespread light to heavy HRD	NONE	Borates do not cure existing infection
Low	Thin PP/JP with no current or historic pine HRD within 1700 feet	NONE	Very low atmospheric spore concentration
Low	Thin PP/JP in mixed species stands; few >14" PP/JP stumps	NONE	Small pine stumps don't create HRD centers; small roots get infected fast with competing organisms
Low	Thin PP/JP in mixed species stands; few pine-to-pine root contacts	NONE	HRD won't spread from stumps that don't have root contact w/ live trees
Low	Thin Doug-fir; incense cedar; sugar pine; other conifers	NONE	Little evidence of HRD problems
Moderate	Salvage low to moderate severity burn (scattered remaining green trees)*	Consider treating >14" PP/JP and > 24" juniper stumps having possible root contact with high-value PP/JP. Treat true fir stumps in stands with no fir HRD	Borates do not cure existing infections. Treating pine stumps near high-value pine trees can protect residual pine from HRD. Large juniper stumps may facilitate spread to adjacent pines.
High	Any cutting, PP/JP, true fir in roadside and powerline corridors (including hazard tree removal and salvage* in low to moderate severity burns)	Treat all PP/JP and > 24" juniper stumps and true fir stumps >14"	Borates prevent infection; lower tolerance for new HRD centers in these areas. Large juniper stumps may facilitate spread to adjacent pines.
High	Thin PP/JP in mixed species stands; many >14" PP/JP stumps and pine-to-pine root contacts; pine HRD within 1700 feet (or distance to nearest HRD not known)	>14" PP/JP stumps (also >24" juniper stumps if present)	Borates prevent infection. Large juniper stumps may facilitate spread to adjacent pines.
High	Thin true fir with no HRD	> 14" fir stumps	Borates prevent infection
Very High	Thin PP/JP; many >14" stumps; pine HRD within 1700 feet (or distance to nearest HRD not known)	>14" PP/JP stumps	Every stump can start HRD centers
Very High	Recreation and Administrative Sites	>3" conifer stumps	Zero tolerance for new HRD centers in these areas means treating smaller stumps of all conifer species
Very High	Thin giant Sequoia groves; treat conifer stumps within 1700 feet of monarch giant sequoia trees	>3" conifer stumps	Zero tolerance for new HRD centers in these areas means treating smaller stumps of all conifer species

* No need to treat stumps of trees with no needles or stumps of trees killed by fire >18 months earlier